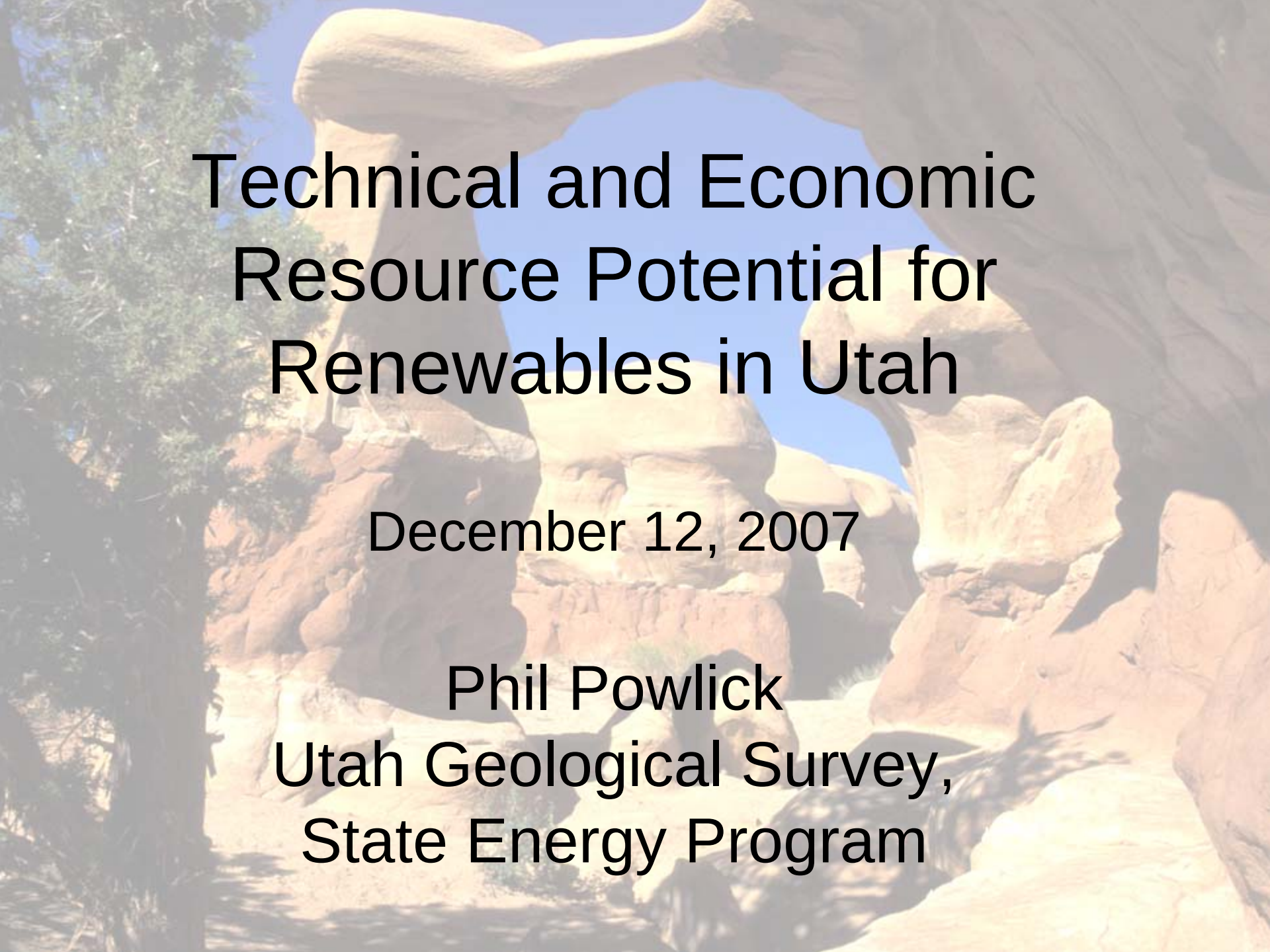


Technical and Economic Resource Potential for Renewables in Utah

December 12, 2007

Phil Powlick
Utah Geological Survey,
State Energy Program

Overview

- Technical Potential = What is possible, economics not considered
- Economic Potential = What is likely to be done given economic parameters
  - Cost per kWh and capacity costs primary in this presentation
  - Other intangible values included where appropriate
  - We DO NOT try to factor in a price for carbon
- Technology review limited
  - Solar PV, Geothermal, Concentrating Solar, Wind
  - Other technologies possible but likely very small portion of electricity portfolio
    - E.g. Biomass, landfill methane, sewer methane

Geothermal Resources

- Focus on best-known development areas
  - Other areas possible, but public data are not available
  - Need for exploration?
- Detailed study done by WGA (Jan. 2006)
  - CDEAC Geothermal Work Group
  - http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

Geothermal Development Costs, Example for Ormat (Nevada)

DRILLING AND WELL FIELD DEVELOPMENT

Medium risk – Investor Financing Possible

- Production/injection wells $1.0 to $3.0M each
- Production wells provide between 3MW and 30MW
- One injection well serves two or more production wells
- Well drilling success averages over 70%
- 3,000 foot average depth – Assume $1.5 M per well

20 MW Nevada project: 7 prod. & 3 inject. wells

Budget for 10 wells @3,000 feet depth is $15M
Timetable including permitting would be 12 to 18 months

Geothermal Development Costs, Example for Ormat (Nevada), cont'd

PROJECT DEVELOPMENT BUDGET 20MW

Uses of Funds

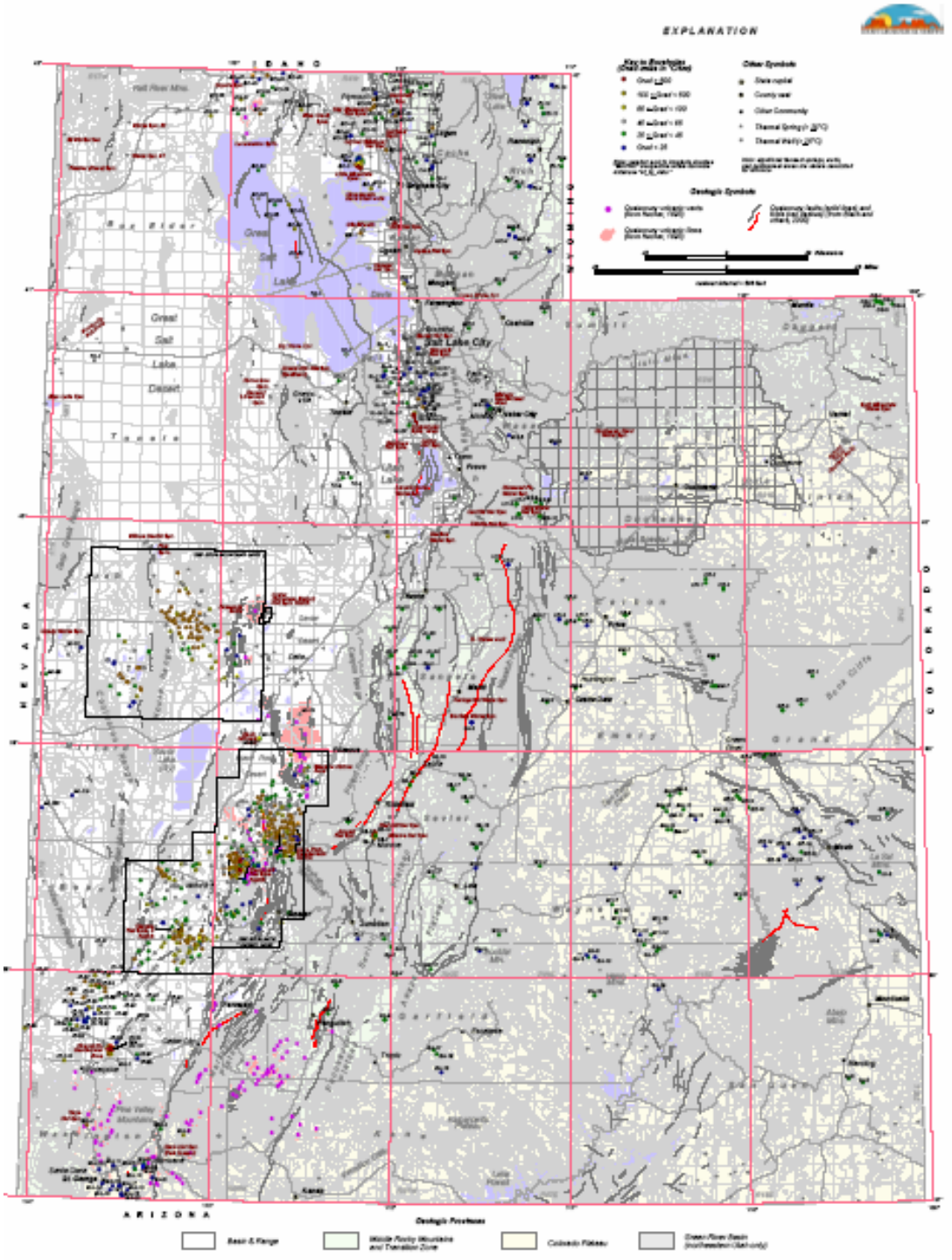
Exploration & resource assessment	**$ 5.0 M**
Well field drilling and development	**15.0**
Power plant, surface facilities, & transm.	**30.0**
Financing "soft costs" including:	**5.0**

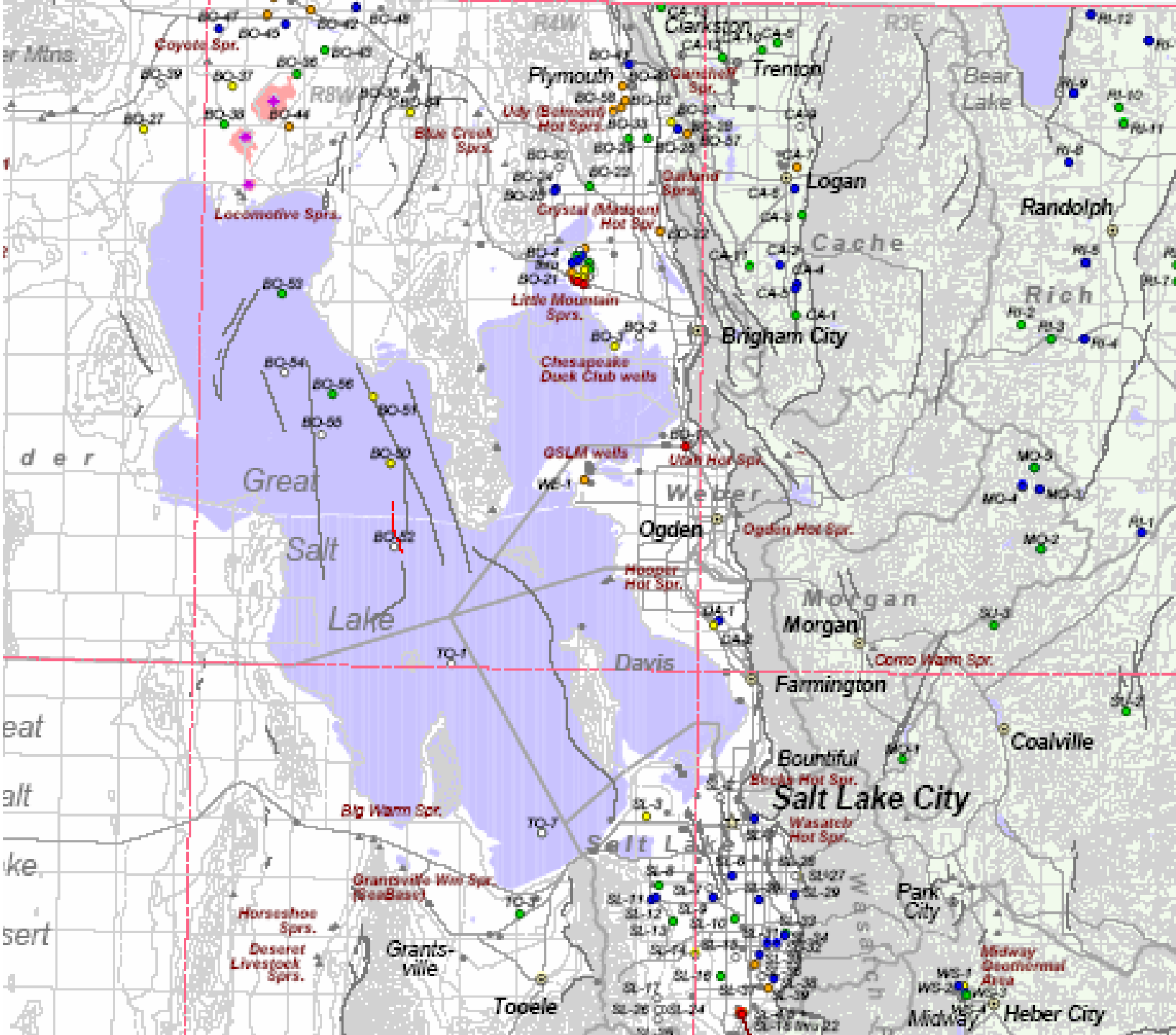
- **Commitment fees**
- **Legal & accounting fees**
- **Consultants, and**
- **Interest during construction**
- **Debt service and operating reserve**

TOTAL *FINANCED* COST FOR 20MW PROJECT $ 55 M

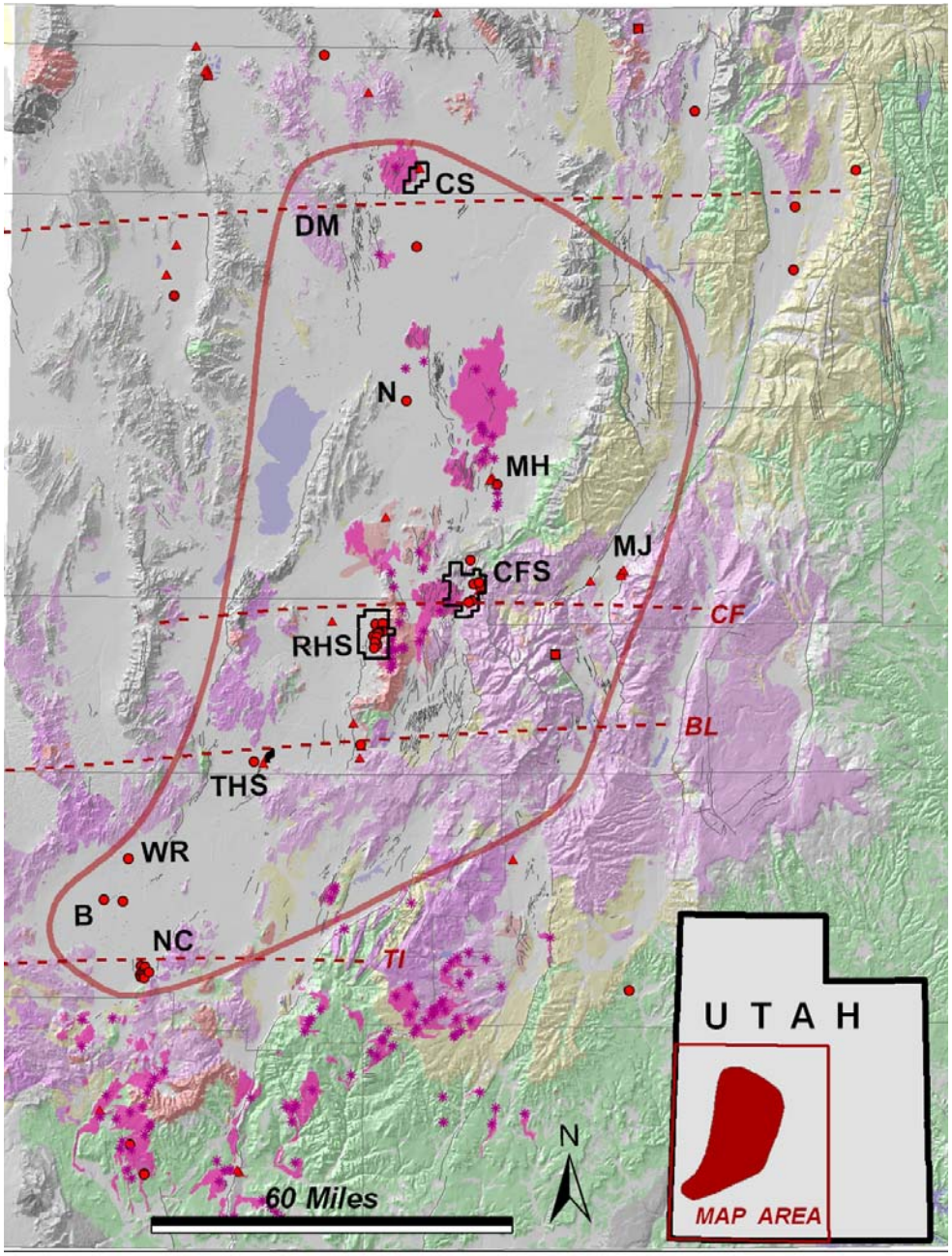
To be provided as construction phase financing

Utah Overall Geothermal Information



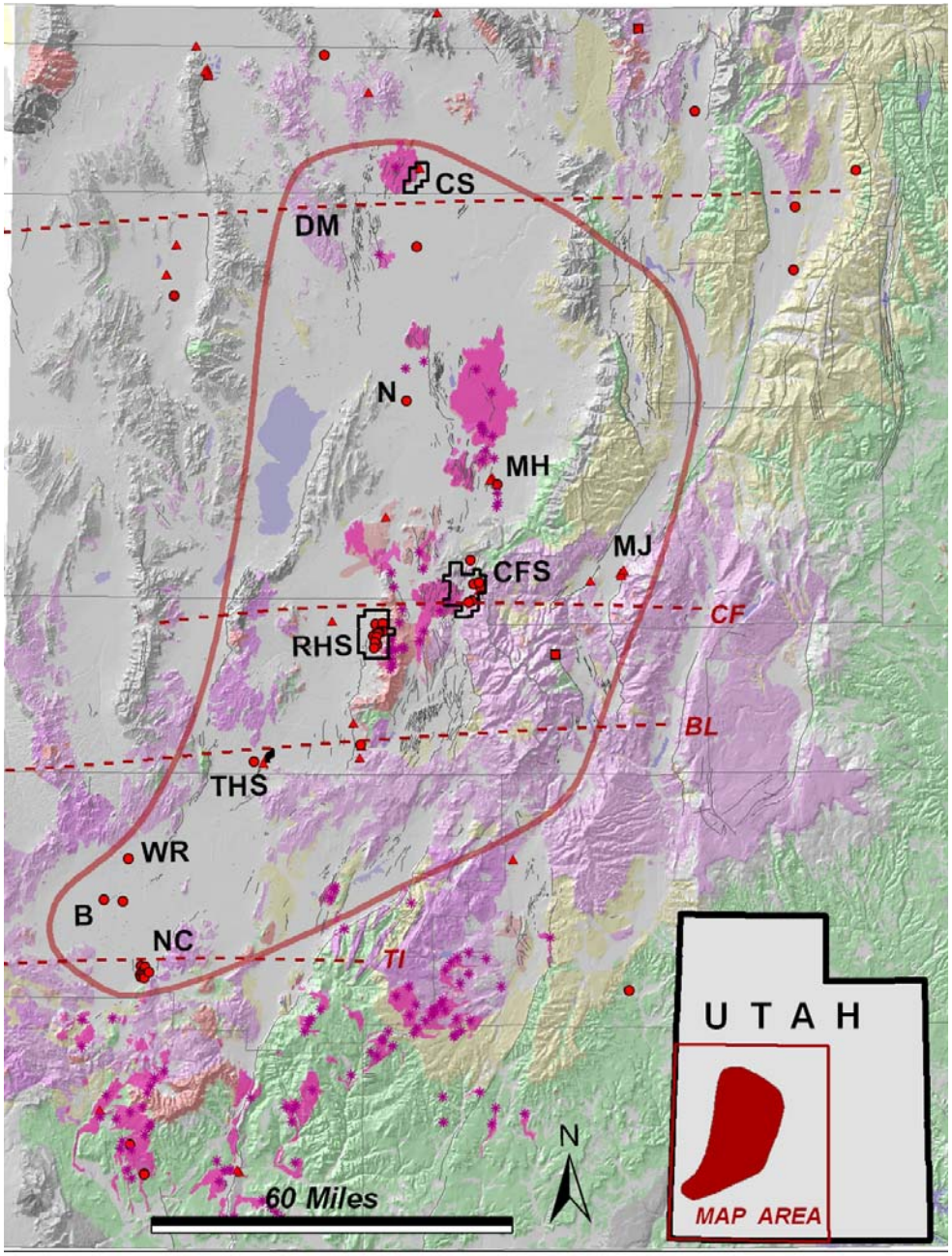

Clarkston
Trenton
Plymouth
Garehill Spr.
Bear Lake
Logan
Randolph
Cache
Rich
Brigham City
Locomotive Spgs.
Little Mountain Spgs.
Chesapeake Duck Club wells
GSLM wells
Utah Hot Spr.
Great Salt Lake
Weber
Ogden
Ogden Hot Spr.
Hooper Hot Spr.
Morgan
Como Warm Spr.
Farmington
Davis
Coalville
Bountiful
Salt Lake City
Wasatch Hot Spr.
Big Warm Spr.
Granger Warm Spr. (NewBasin)
Horseshoe Spgs.
Deseret Livestock Spgs.
Grantsville
Tooele
Park City
Midway Geothermal Area
Midway
Heber City

Sevier Thermal Area



- Located in Southwestern Utah
- Eastern Basin & Range province and Transition Zone
- Has most of the identified moderate and high-temperature geothermal systems in Utah

STA Geothermal Areas



- RHS - Roosevelt Hot Springs
- CFS – Cove Fort-Sulphurdale
- DM - Drum Mtns.
- CS - Crater Springs
- N - Neels RR Siding Well
- MH - Meadow-Hatton
- MJ - Monroe-Joseph
- THS - Thermo Hot Springs
- B – Beryl
- WR - Woods Ranch
- N - Newcastle

WGA Geothermal Summary - Utah

Resource Area	Resource Capacity Values (MW)		Expansion	Cost Allocations	
	Near-Market cost up to 8 c/kWh online within 10 years	Longer-Term cost up to 20 c/kWh online within 20 years		Capital	O & M
				$/kW	cent/kW-hr
Cove Fort-Sulphurdale	50	200	e	3500	2.2
Roosevelt Hot Springs	100	250	e	3500	1.8
Thermo Hot Springs	50	100		3500	2.2
Newcastle	10	20		3500	2.2
Other (Monroe, Mineral Mts., etc.)	20	50		3500	2.2
Utah Total	*230*	*620*			

WGS Geothermal Estimate in Perspective

- 230 MW of capacity by 2016

  @ 85% CF= 1,713 Gwh / yr

  – 6.5% of 2006 Utah consumption (26,361 Gwh)
  – 5.3% of 2016 Utah consumption (32,134 Gwh)

- 620 MW of capacity by 2026

  @ 85 CF= 4,617 Gwh / yr

  – 17.5% of 2006 Utah consumption (26,361 Gwh)
  – 11.8% of 2026 Utah consumption (39,171 Gwh)

Solar PV Potential

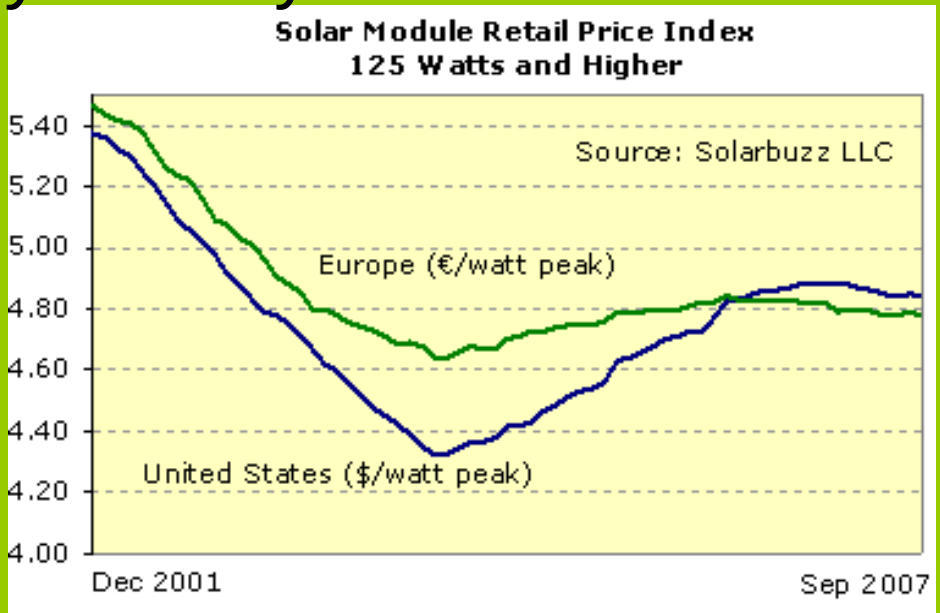
- Technical potential is vast…
  - If you want to cover most of the state in solar panels
- Large technical potential even placing PV panels only on existing buildings
  - If 1 kW on each existing homes in UT (785,000), 785 MW capacity (11.5% of current)
    - But low capacity factor; avg. = 17%
    - Generation would = 1,169 GWh or 4.4% of current consumption (3.7% of 2015 consumption)
    - Cost = $6.28 billion (assuming $8,000 / kW capacity)
    - Cost borne through current tax credits; Utah = $1.57B, Fed = $1.41B

Solar PV Potential, cont'd

- Costs can be reduced somewhat by installing only on new buildings
  - Assume all new homes built in UT 2008-2015 have 1 kW PV installed
    - @ 24,000 / year; 192,000 total
    - 1 kW per home @ $7,000 / kW
    - 192 MW capacity; 285 GWh in 2015
      - 1.1% of current consumption; 0.9% of 2015 consumption
    - Total cost = $1.34 billion
    - Cost borne through current tax credits; Utah = $336M, Fed = $302M

PV Cost Projections

- WGA Solar Task Force Report
  - Projects 75 MW for capacity potential for Utah by 2015
  - Shows current costs @ 20 to 30 cents / kWh
  - Projects drop to 10 to 15 cents by 2015 IF PV deployment grows by 32% / year in the West
    - Assumes prices drop as production efficiency climbs
    - Or will increasing demand cause prices to rise ?



More Cost Estimates

- SEIA
  - Central PV Current = 20 to 30 cents
  - Distributed PV = 20 to 50 cents
- UT SEP (price / kWh for 20 yr ,simple payback)
  - Small PV, no financing, fed credits = 23.5 cents
  - Small PV, 7% interest, fed credits = 43.7 cents
  - Large PV, no financing, fed credits = 18.0 cents
  - Large PV, 7% interest, fed credits = 35.0 cents

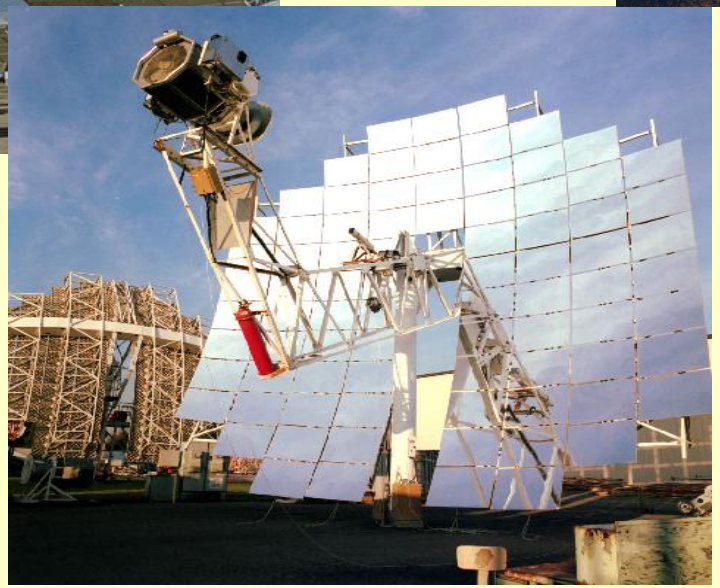
What is Value of PV?

- Zero emission (comparable to other RE)
- Solar PV is roughly peak following
  - Mona hub prices (wholesale), past year
    - Peak = 6.3 cents / kWh
    - Offpeak = 3.8 cents / kWh
    - Other regional hub prices comparable
- Resource availability more predictable than wind
  - But less so than geothermal
- Distributed PV improves robustness of grid
  - Can reduce need for new peaking capacity
  - Local back-up power
  - Reduces need for transmission and T&D costs
- Resource is widespread
  - Systems can be deployed where needed

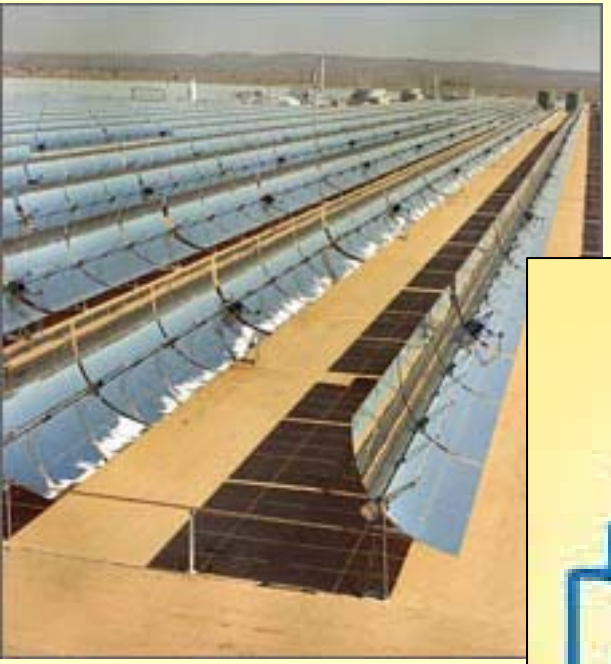
PV Summary

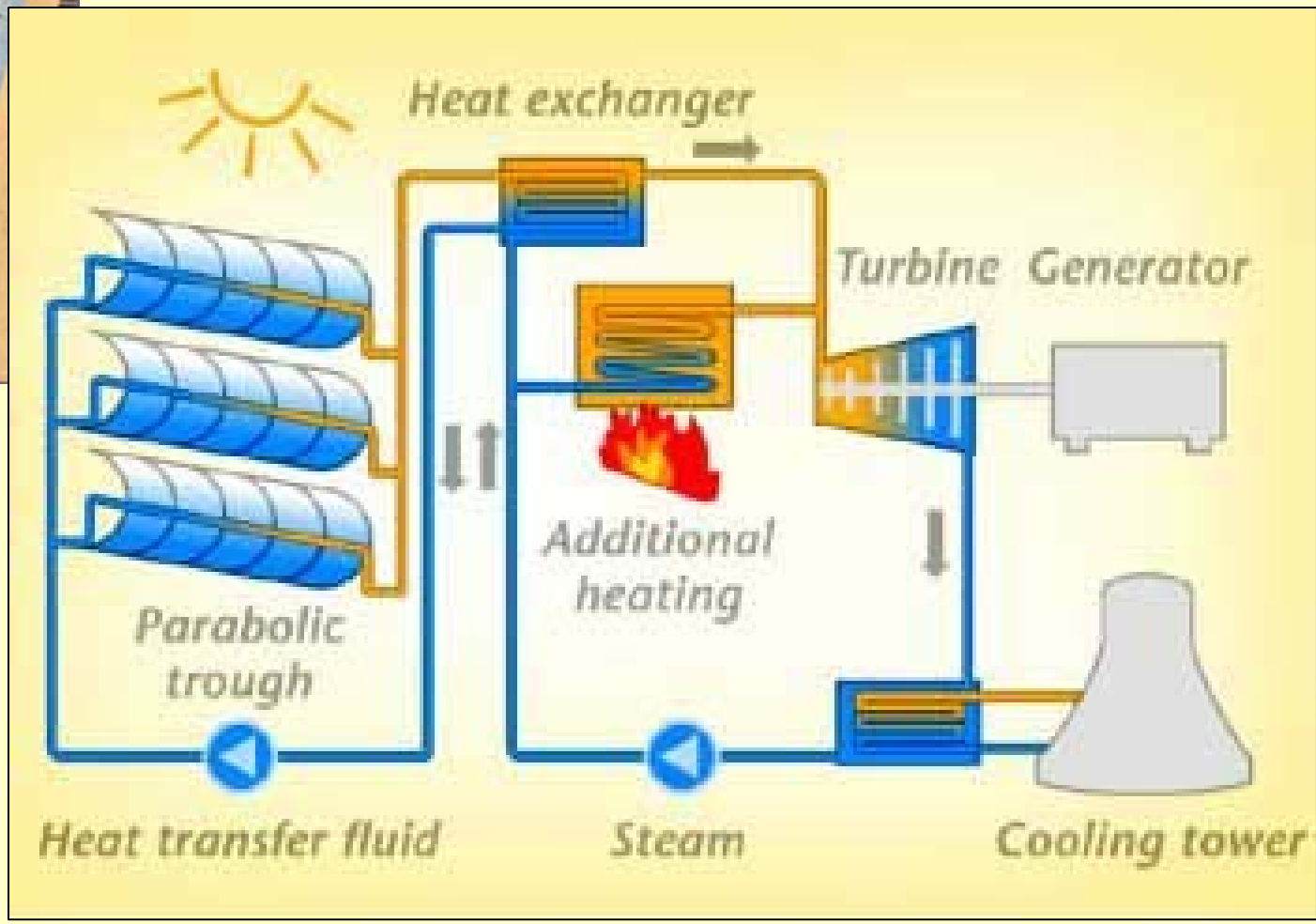
- Technical potential is vast
- Technological hurdles few
- Capacity and kWh price is high
- But non-monetized benefits exist
- Key Question: How much are PV benefits worth when compared to other alternatives (fossil and renewable)?

Concentrating Solar Power in Utah



Concentrating Solar Power (CSP)





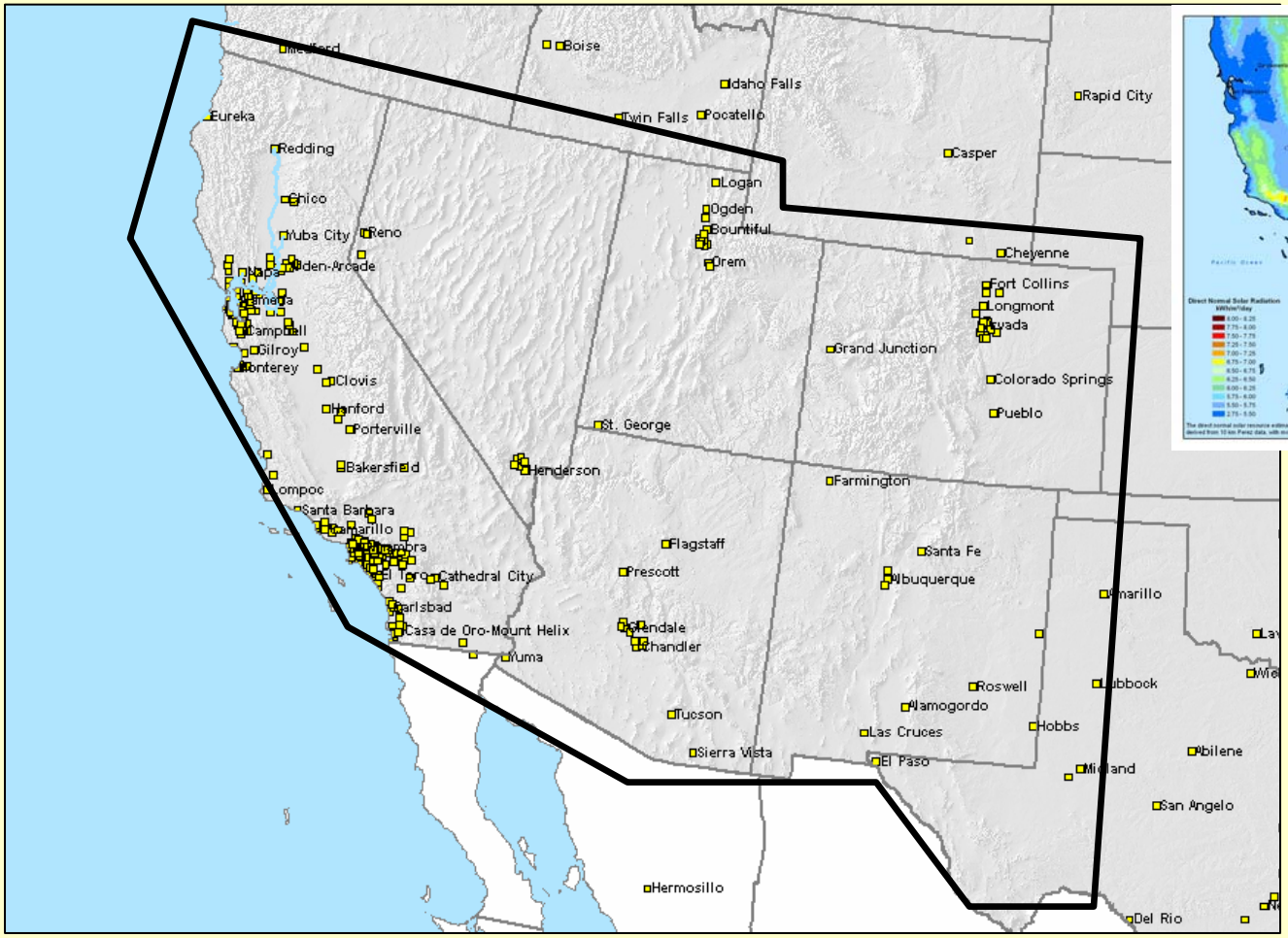
DOE—NREL study of CSP in the Southwest

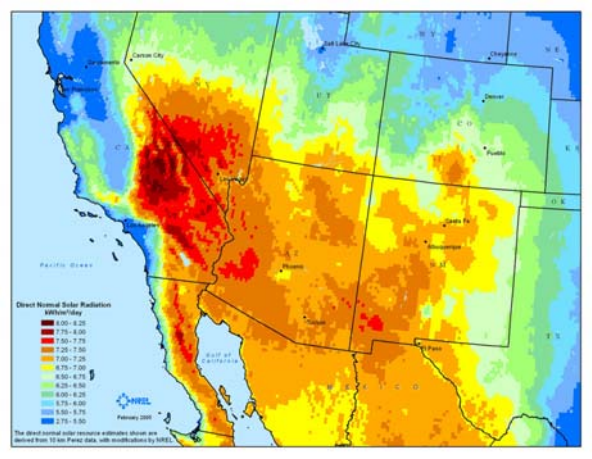
What is the cost of energy for each increment in CSP capacity?

Analysis requires knowledge of the following:

- Solar Resource
- Land Availability
- Proximity to Transmission
- Availability of Transmission
- Cost to Generate Power

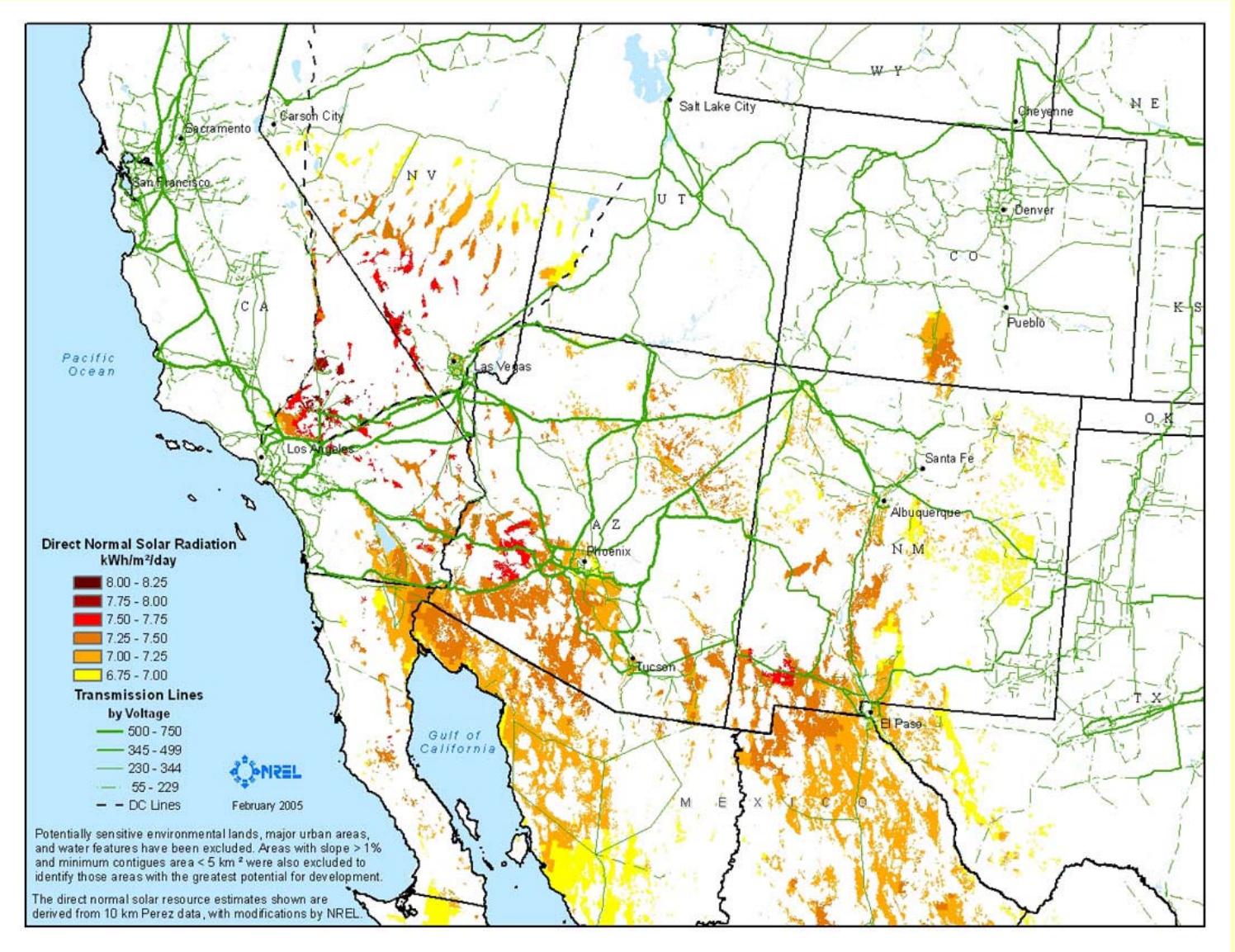
DOE CSP Study
1000MW Analysis





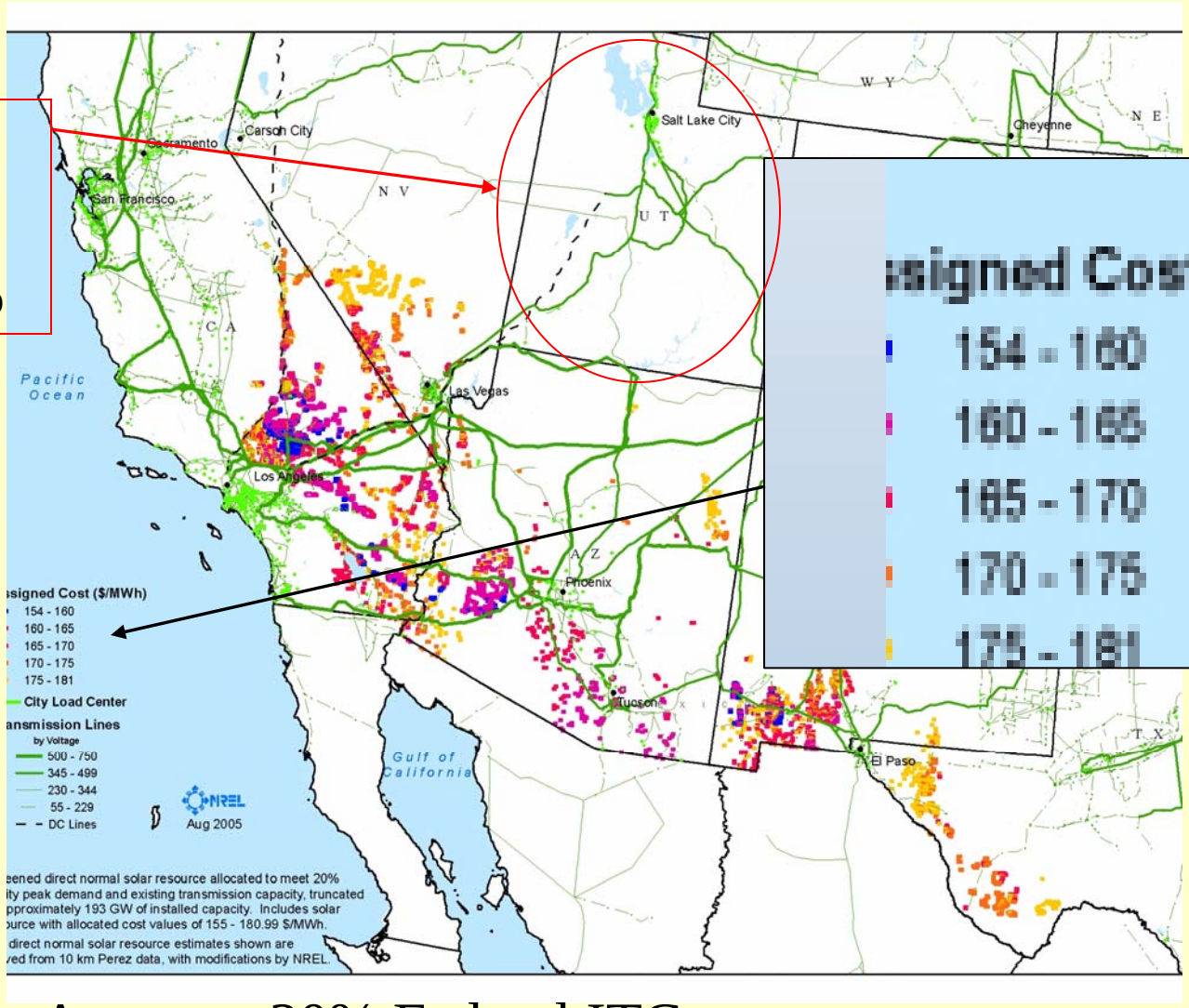
Southwest Solar Resources

Prior plus Slope < 1%



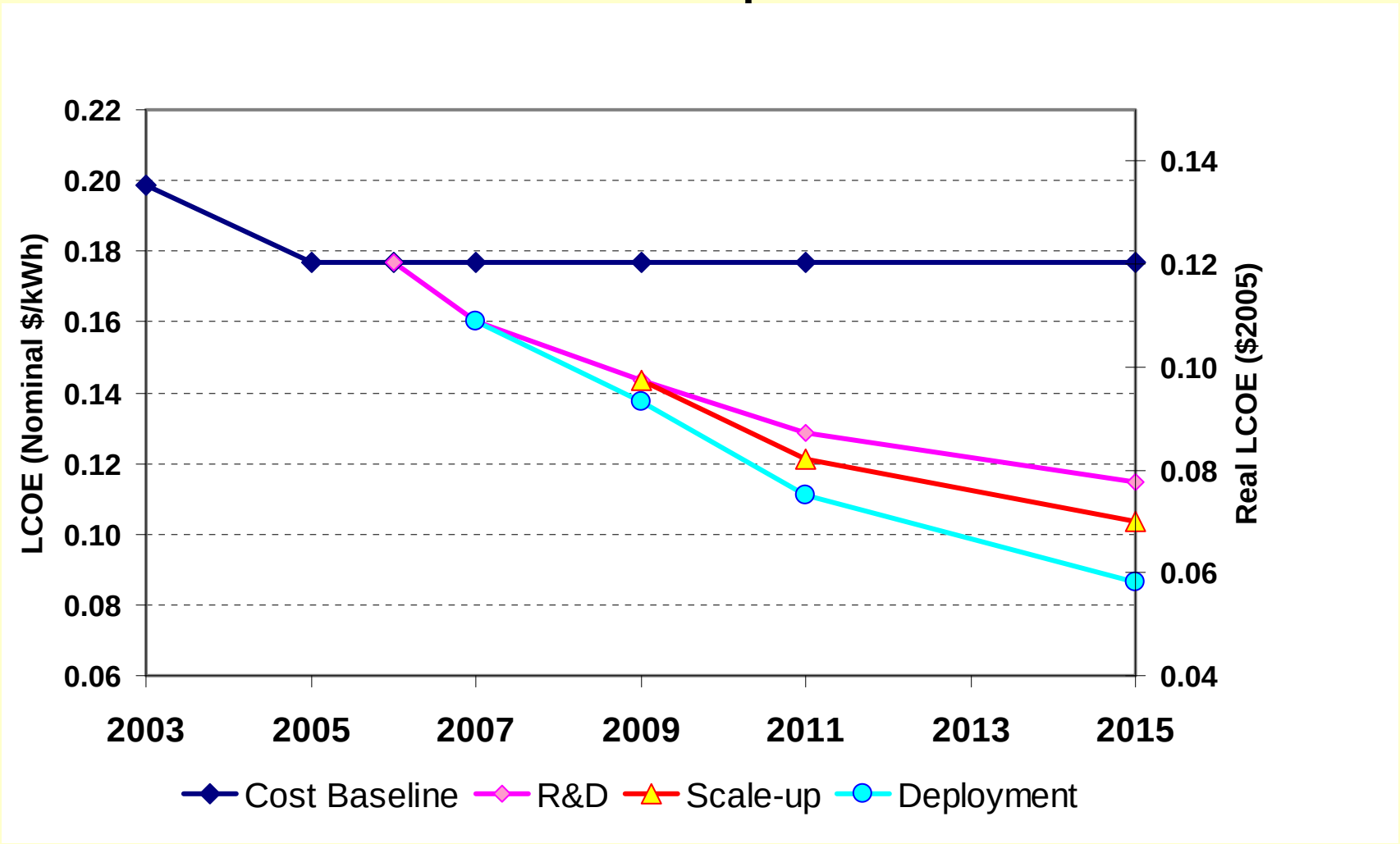
DOE's Findings for Optimal Locations for 2GWs of CSP Capacity in Southwest U.S.*

Models shows no UT development under scenario



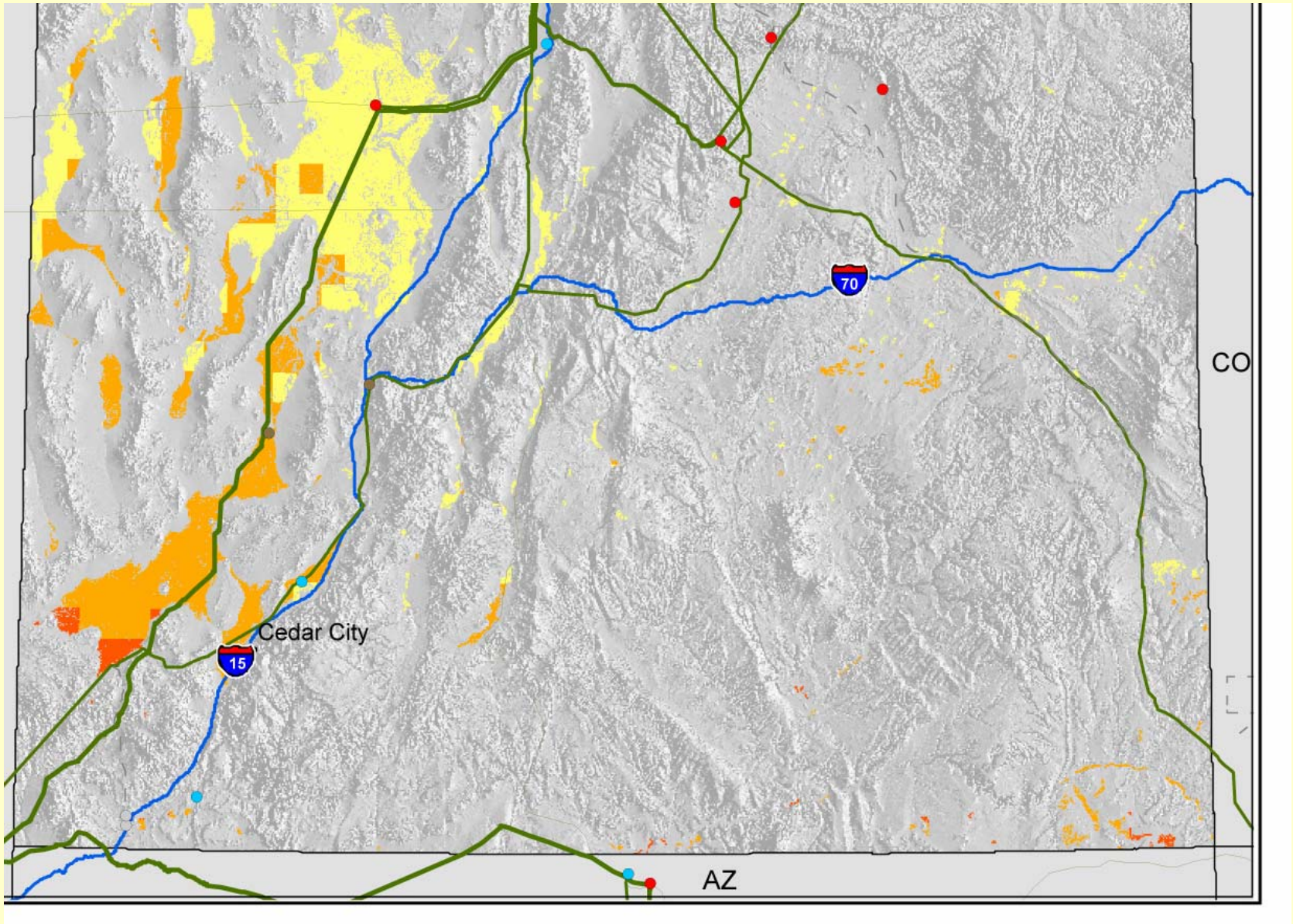
Assumes 30% Federal ITC

DOE's Cost Reduction Projections w/ 2000MW market penetration*

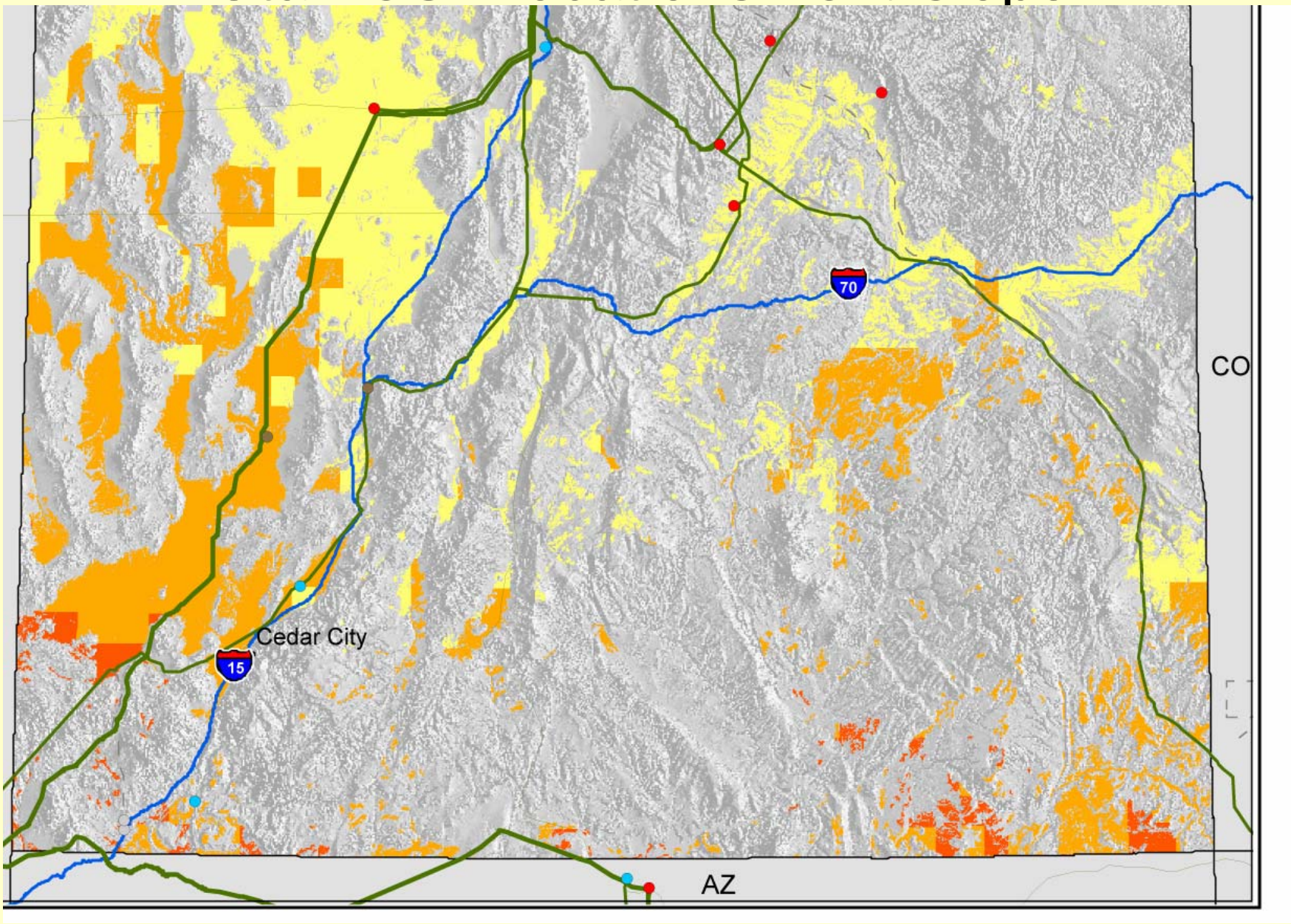


*using solar resource of Barstow, CA (7.75-8.06 kW/M2/day. Utah's best is 7.25-7.49).

Utah CSP locations <1% slope



Utah CSP locations <3% slope



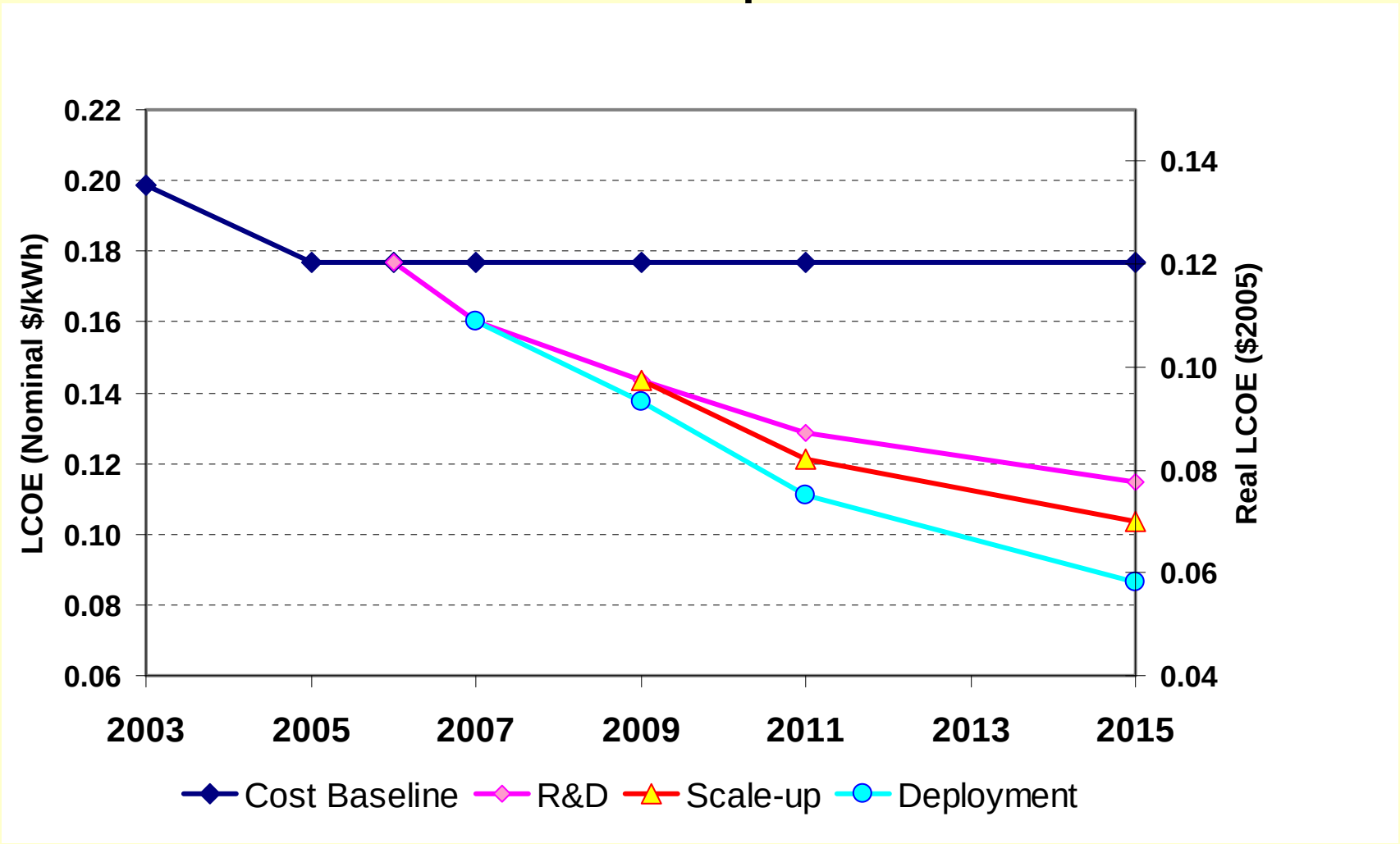
Estimated costs for California

- Based on NREL consultations
- With 30% federal tax credits
- 100-200MW minimum with no thermal storage
- 12-13 cents / kWh (generated cost)
- Costs are going back up due to materials and limited developers in the market
- Developers are going for larger developments, =>100MW
- Likely deployments @ 2011

Utah vs. Nevada Current Costs

- Nevada Solar One 65 MW CSP
  - With no thermal energy storage, 25% Cap. Factor
- Nevada Solar One cost approx. $3.5 million per MW
  - Cost = $2.45 million/MW after federal tax credits
- Assuming 9% post-tax IRR is needed
  - Cost = 14.4 cents / kWh for a flat rate 20-year PPA
- Utah's best solar resource would allow for a 20% CF in a CSP plant (without storage)
- 65MW CSP plant with similar cost per MW of generating capacity would cost 18.2 cents / kWh

DOE's Cost Reduction Projections w/ 2000MW market penetration*



*using solar resource of Barstow, CA (7.75-8.06 kW/M2/day. Utah's best is 7.25-7.49).

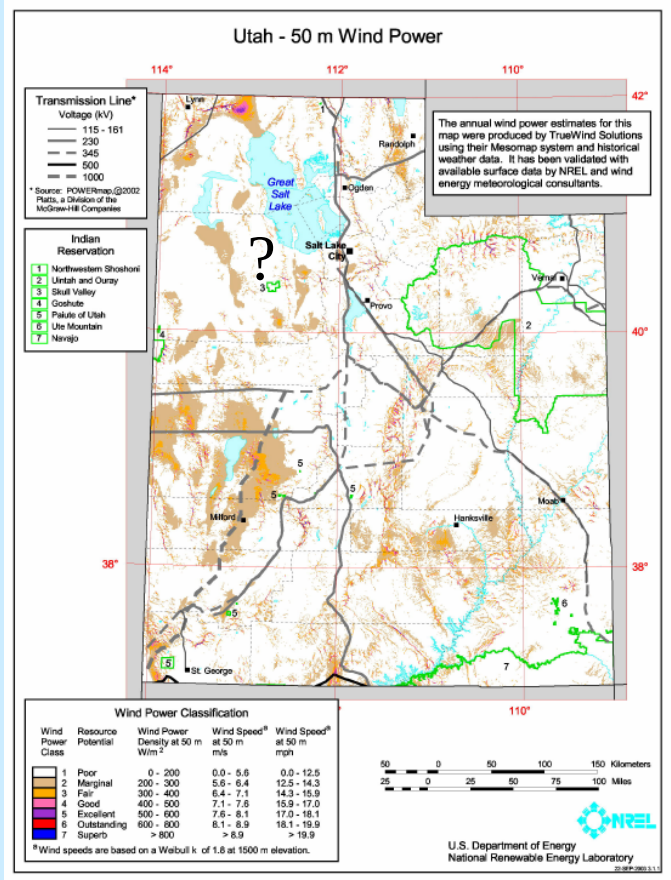
Utah Wind Resource Assessment

Utah State Energy Program

Utah Geological Survey

Utah's Estimated Wind Resources

- Utah's Wind Map
- Computer model
  - Mesoscale data
  - Model uses Jet stream weather patterns
  - Some actual wind data
  - Can be highly inaccurate
  - Developers do not use it



Estimates by the DOE

- WGA's Clean and Diversified Wind Task Force, (Milligan, et al. 2006). Estimated 100 to 570 MW for Utah. Model based on filtering State Wind Map
- Recent DOE WinDS modeling estimated 2.6 GW for Utah by 2024. Based on filtering Utah Wind Map
- Wind Powering America Update report estimates 100-1000 MW, (Flowers. August, 2007).
  - Flowers orally estimated 2,450 MW, 11/30/07

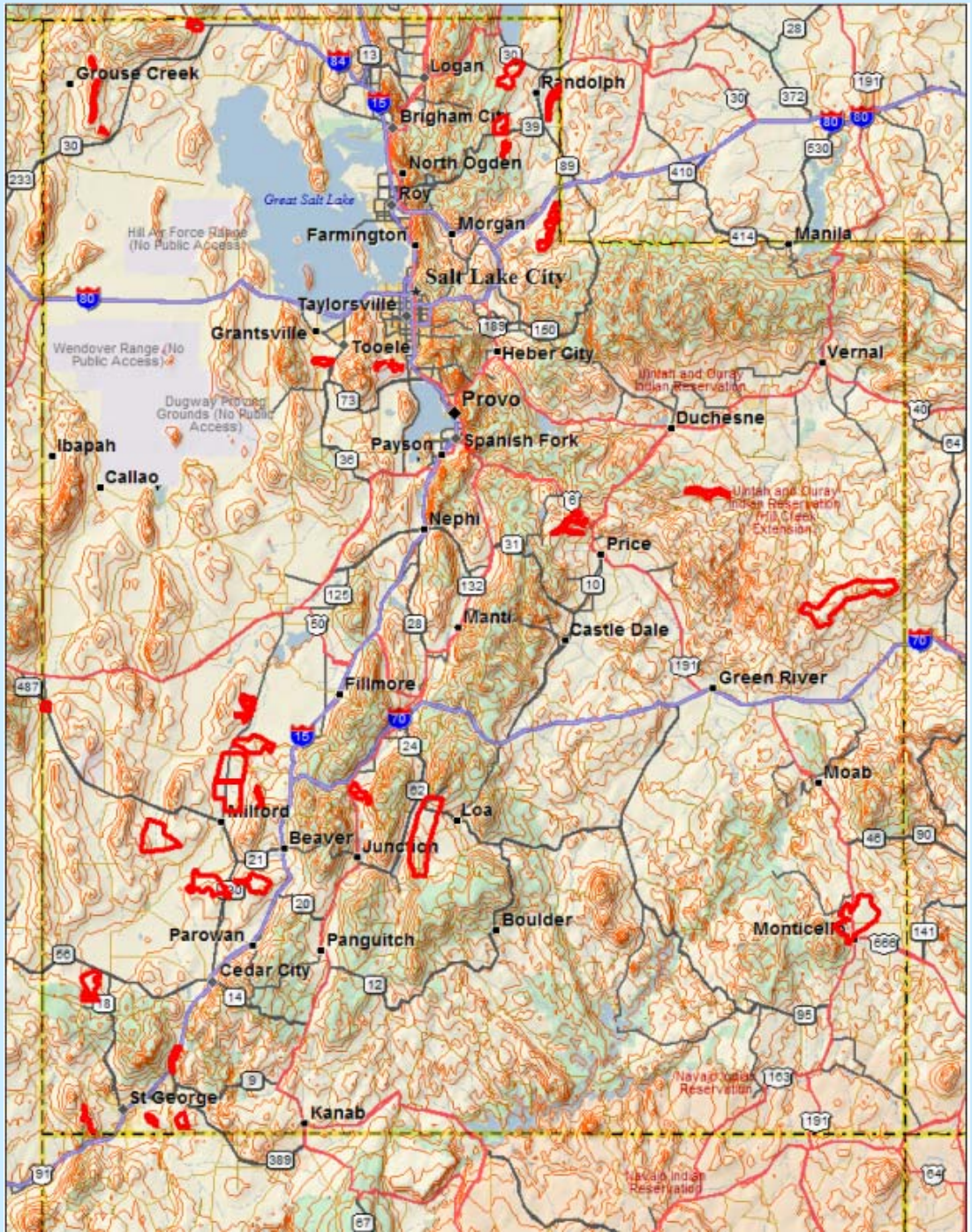
SEP's Methodology for Wind Assesment

- Potential areas identified by SEP and industry
- Data collected from the field (SEP and/or industry)
- Collaborated with industry for data and tech support
  - Thanks to Rich Simon & Tracy Livingston
- 32 potential sites selected throughout the state
- One turbine model used (Clipper C99) 80m hub height
- Two formulas used for turbine placement (ridgelines and open areas)
- Net Capacity Factor Used to estimate MWh production

Methodology for Wind Assessment, cont'd

- Transmission length estimated @ $1million/mile
- Created 2 scenarios for turbine deployment
  - Scenario 1 assumes maximum turbines / km^2
  - Scenario 2 assumes 50% of maximum likely for speculative projects
    - Land use, geology, aesthetics, siting issues, etc.
  - Economic Assumptions
    - 9% post-tax rate of return
    - 20-year project life
    - Federal production tax credits only
    - No REC's – Costs reflect total cost to UT ratepayers

Wind Study Areas



Results—Wind Development Scenario 1

•Maximum deployment scenario 1 estimates 6.8 GW nameplate capacity technically possible

Total MW	Net Capacity Factor (%)	MWh Generated	Net Annual GHG emission reduction (tCO2 equivalent to natural gas plant)
6795	**27.89**	**16,128,857**	**8,359,177**

•Utah 2006 electrical consumption = 26,361GWh

-Scenario provides 61% of Utah's electrical demand in 2006

-Scenario provides 51% of Utah's electrical demand in 2015

•Net annual GHG emission reduction of 8.4 Million Metric Tons of CO2

-22% of Utah Electricity Sector's estimated GHG emissions in 2020

Results—Wind Development Scenario 2

Scenario 2 conservatively estimates 3.6 GW of nameplate capacity technically possible

Total MW	Net Capacity Factor (%)	MWh Generated	Net Annual GHG emission reduction (tCO2 equivalent to natural gas plant)
3661	**27.89**	**8,064,429**	**4,344,252**

- Utah 2006 electrical consumption = 26,361GWh
  - -Scenario 2 provides 30.5% of Utah's electrical consumption in 2006
  - -Scenario 2 would produce 25.5% of electricity consumed in 2015
- Net annual GHG emission reduction of 4.3 Million Metric Tons of CO2
  - -12% of Utah Electricity Sector's estimated GHG emissions in 2020

Results—Estimated Cost of Development for Scenario 2

- $/MWh based on Post-tax IRR of 9%
- Includes current Federal (but not Utah) PTC
- Assumed $1.8 million/MW installed capacity + transmission ($500,000 to 1 million/mile)
- Pro forma includes other costs, i.e. property taxes, O&M, MACRS, developer fees, etc.
- No REC price
  - For developer is crucial piece of economics
  - For policy discussion, REC price is ultimately paid by consumer

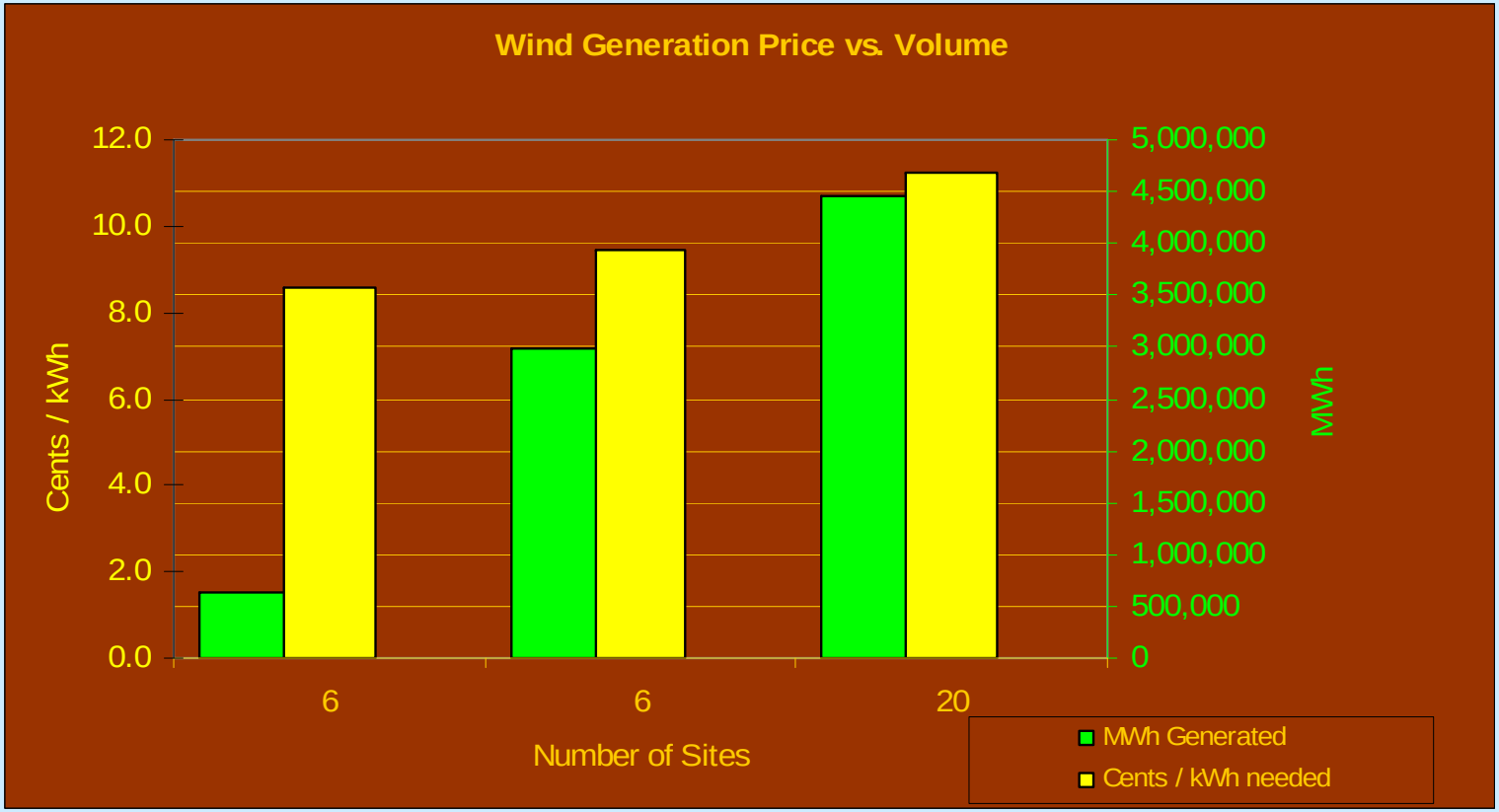
Results—Estimated Cost of Development for Scenario 2

Cents / kWh	Sites	Capacity (MW)	Avg Capacity Factor	MWh Generated	Cents / kWh needed
>10	20	2,014	27.5	4,446,672	11.2
9 to 10	6	1,147	29.5	2,994,594	9.5
8 to 9	6	237	31	623,164	8.6
Total/Average	**32**	**3,398**	**27.97**	**8,064,429**	**10.4**

- A few high capacity, economic sites exist
- Biggest cost problems…
  - Resource quality (best in UT = 33% capacity)
  - Transmission – Most wind areas far from load

Results—Estimated Prices and Volumes

Cents / kWh	Sites	Capacity (MW)	Avg Capacity Factor	MWh Generated	Cents / kWh needed
>10	20	2,014	27.5	4,446,672	11.2
9 to 10	6	1,147	29.5	2,994,594	9.5
8 to 9	6	237	31	623,164	8.6
Total/Average	**32**	**3,398**	**27.97**	**8,064,429**	**10.4**



National Cost Comparison

- 2007 DOE Wiser & Bolinger report capacity-weighted average sales price for 2006 was 4.9 cents / kWh (with a range of 3.0 to 6.4 cents).
- Report concludes that cost (therefore prices) are rising
  - Old projects, fixed, low price contracts
  - New project prices rising quickly
- Construction prices continue to go up
  - @ $1,000 / MW (capacity) in 2002
  - Now @ $1,800/MW.
  - How much further will they go?

Comparing Renewables' Current Costs and Production for Utah, New Units

Technology	Capital Cost ($/W capacity)	Capacity Factor	Unit Cost (cents/kWh)
Conc. Solar	2.4 – 2.6	25 – 35%	14.0 – 18.0
Wind	1.8 – 1.9	30 – 35%	8.0 – 11.0
Geothermal	3.0 – 4.5	80 – 90%	6.0 – 8.0
Solar PV	8.0 – 10.0	17 – 20%	30.0 – 40.0
Coal	2.8 – 3.5	85 – 90%	5.2 - 6.3
CC NG	0.55 – 0.65	60 – 85%	6.8 – 7.5

Summary

- There is no magic bullet
  - Utah has abundant renewable resources
    - But for no technology are they exceptional
  - Some low-cost projects possible
    - But likely to account for relatively small portion of electricity demand
  - Large-scale renewables projects will cost more
- For perspective…
  - Utah has cheap electricity right now
    - Utah = 5.99 cents / kWh
    - National Average = 8.85 cents / kWh
  - Costs likely to rise in future, regardless of move to renewable resources
    - Same construction cost issues for wind, coal, gas

Summary, cont'd

- What is the value of renewables vs. fossil fuels?
  - Zero-emission: Key in carbon future
  - Risk hedging
    - Short term – Carbon risk mitigation
    - Long term – Price stability
      - Renewables typically 20 year PPA's, fixed prices
- Future risks, fossil fuels
  - Carbon
  - Fuel prices
    - Gas a given
    - Coal prices also may be volatile
      - Industry moving away from 10 year contracts

Summary, cont'd 2

- Reliability Issues
  - Some renewables intermittent (not geothermal)
  - Wind least predictable; solar in between
- Ways around reliability?
  - Nat gas backup
  - Renewable type diversity – Design to resources
    - E.g. Match solar with nightime wind
  - Storage – Thermal, capacitors, water, air
- Reliability is not a deal killer for renewables